Featured Articles

Home Photovoltaic Power Generation System

Kenji Shiraishi
Satoru Usui
Akihiko Kanouda

OVERVIEW: In August of 2012, Hitachi Appliances, Inc. established a business that markets home photovoltaic power generation systems under the Hitachi brand. The systems have been subject to ongoing improvements, including not only the development of a power conditioner, peripheral equipment, installation fittings, and other structural components, but also the establishment of an in-house and external infrastructure that includes a product warranty scheme, training and accreditation schemes for sales and installation, and sales promotion tools.

INTRODUCTION

HITACHI'S home appliance and air conditioning products make extensive use of the highly efficient inverter technology it has built up over time. Hitachi embarked on a project in 2010 to develop a power conditioner that incorporates this superior technology and to create a Hitachi-brand home photovoltaic power generation system. The power conditioner is a key component of photovoltaic power generation systems because it converts the direct current (DC) power generated by the photovoltaic modules to the alternating current (AC) power used in the home. The objective was to commercialize a distinctive photovoltaic power generation system by bringing together technical capabilities from across Hitachi in order to develop a power conditioner that would be superior to its competitors.

To establish a business to handle this Hitachi-brand home photovoltaic power generation system, Hitachi first developed a power conditioner, peripheral equipment, installation fittings, and a long-term product warranty scheme, and then set up its own training and accreditation schemes for sales and installation in order to provide in-house and external sales infrastructures.

Having undertaken these business preparations, Hitachi commenced sale of its branded home photovoltaic power generation system in August 2012. Since then, the business has made ongoing improvements to way of selling, extending the range of photovoltaic modules and installation fittings, and sale promotion infrastructure in response to customer wishes (see Fig.1).

This article describes the Hitachi home photovoltaic power generation system and the sales infrastructure that underpins the business.

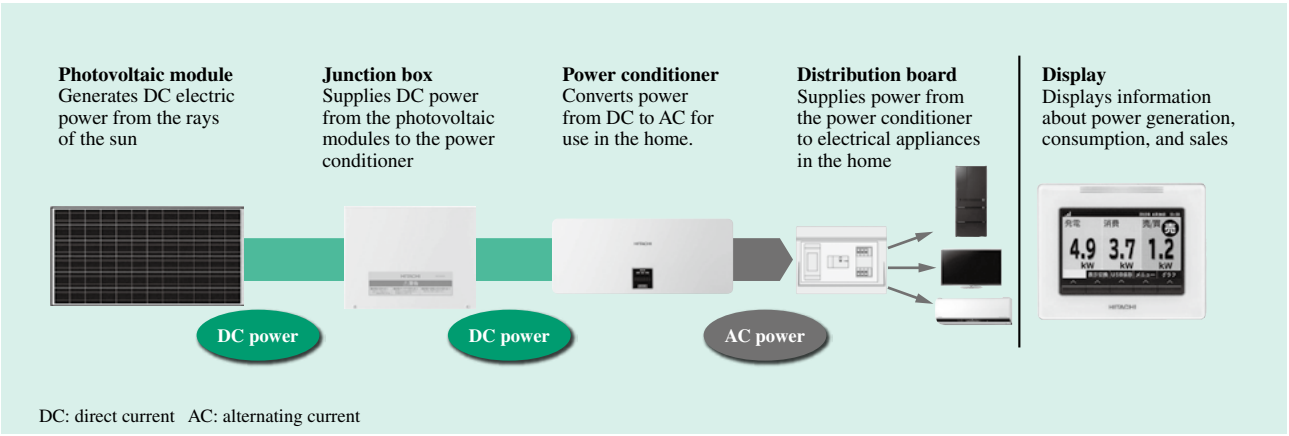
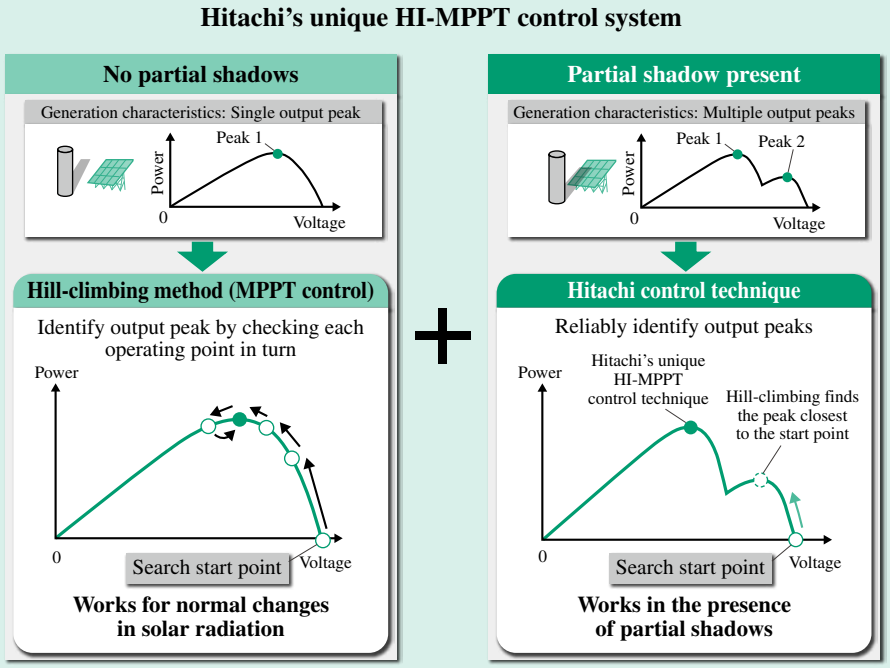


Fig. 1—Equipment Included in Photovoltaic Power Generation System.
The system includes photovoltaic modules, a junction box, and a power conditioner. The electric power distribution board is not included.



MPPT: maximum power point tracking

Fig. 2—Features of HI-MPPT Control Based on Photovoltaic Module Generation Characteristics.
The presence of partial shadows on the modules results in multiple power output peaks. The amount of electric power generated can be increased by combining the previous hill-climbing MPPT method with HI-MPPT control, which reliably finds the highest output peak by searching for changes in the peak at appropriate times.

HITACHI HOME PHOTOVOLTAIC POWER GENERATION SYSTEM

Development of Power Conditioner

The objective of product development was to maximize the amount of power produced by the photovoltaic power generation system.

The power conditioner has two functions: to extract more DC power from the photovoltaic modules and to convert that DC power to AC. Hitachi focused on these two functions in order to develop a product in which they would both contribute to maximizing power generation.

The factors that influence photovoltaic power generation include not only the variations in solar radiation because of weather conditions, but also partial shadows on the photovoltaic modules cast by objects such as trees or power poles. In response, Hitachi developed HI-MPPT, its own maximum power point tracking (MPPT) control system, in order to increase the amount of power produced even when partial shadows occur at different times of the day (see Fig. 2).

The conventional MPPT control method is to vary the voltage when searching for the peak power output of the photovoltaic modules. If only one peak exists, then this method will successfully locate the peak from the search starting point. When the photovoltaic modules are partially shaded, however, a number of peaks (local maximums) may exist, and this can prevent the search from finding the point of maximum output. Hitachi's HI-MPPT control system searches for changes in the peak at appropriate times in order to adjust the operating voltage to the value that generates the most power, even in the presence of more than one peak. This minimizes lost power generation and produces a greater amount of electric power.

The converter that steps up the voltage of the DC power from the photovoltaic modules uses a silicon carbide Schottky barrier diode (SiC-SBD) to significantly reduce the recovery losses in switching. This permits the use of a high switching frequency (40 kHz), allowing a smaller DC reactor and lower copper losses. For the inverter that converts the DC power to AC, meanwhile, Hitachi has developed a new pulse width modulation (PWM) control technology that minimizes distortion on the output current waveform despite having a switching frequency that is only one-quarter of that used previously. Through these features, Hitachi has created a power conditioner with a rated conversion efficiency of 96%, which is top-class in the industry (see Fig. 3).

Hitachi went on to release a new model in February 2014 that fulfills the requirements for multiple grid-interconnection systems defined by the Grid-interconnection Code(JEAC 9701-2012, Japan Electric Association). Along with pursuing even higher efficiency, Hitachi plans to continue developing its

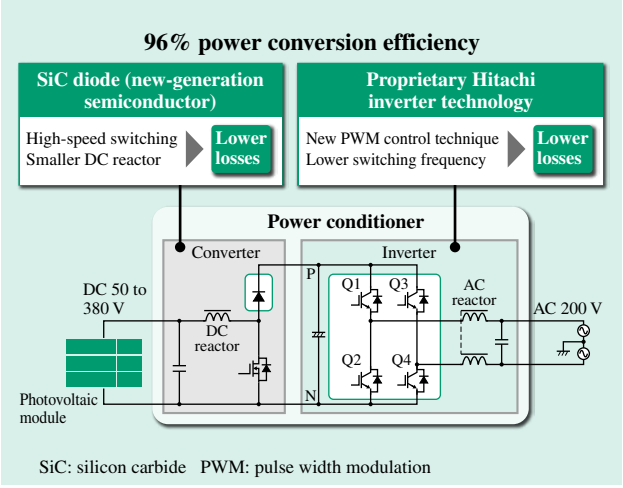


Fig. 3—Improvements to Power Conversion Efficiency of Power Conditioner.
Use of a SiC diode in the converter and a newly developed PWM control technique in the inverter achieved a power conversion efficiency of 96%.

product range, including the addition of models that are suitable for outdoor installation.

Development of Installation Fittings to Suit Different Rooftops

Hitachi has developed its own rails and fasteners for mounting the photovoltaic modules.

Using its own unique horizontal rail design allows Hitachi to take account of considerations such as the ease of positioning the photovoltaic modules during installation, and their appearance once installed. To make installation more efficient, Hitachi has also chosen to use the same fasteners for attaching the rails and modules. It has also provided new fasteners that are designed to simplify minor adjustments to suit different roofing materials when fitting the rails to the roofing (see Fig. 4).

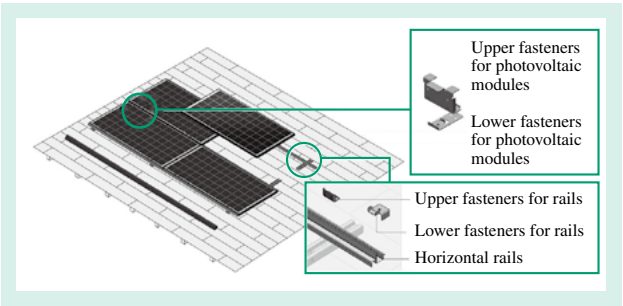


Fig. 4—Horizontal Rails and Fasteners.
Hitachi developed and made available its own installation fittings to make the photovoltaic modules easier to install and improve their appearance once installed.

Hitachi is working to expand the range of roofs on which the modules can be installed, with other additions to the product range including installation fittings for folded-plate roofs and clamps for metal roofs.

Commercialization of Hitachi Photovoltaic Modules

When it first went on the market, the Hitachi photovoltaic power generation system used photovoltaic modules from other suppliers. Since November 2013, however, it has been selling its own modules, which are produced under an original equipment manufacturing (OEM) arrangement. The product range offers customers a choice of photovoltaic modules to suit their needs, with modules available in a 210-W monocrystalline model, a half-size 105-W model, and a 255-W polycrystalline model. They come with a 25-year linear output warranty*.

SALES TOOLS AND SALES SUPPORT SYSTEMS

Along with providing product information by the usual means, including a catalog and website, Hitachi has also developed tools and introduced services to assist retailers and sales companies. The tools include a simple power generation simulator and the Hitachi Solar System (HSS) sales support system. The services include support for system design, utility cost simulation, summary quotations based on material selection, and subsidy application documents (see Fig. 5).

Simple Power Generation Simulator

The website includes a simple power generation simulator available for public use. When the user selects the roof of the customer's home on a Google satellite image, the simulator estimates how many photovoltaic modules can be installed and how much power they can generate (see Fig. 6).

Assistance Provided by HSS Sales Support System

Hitachi has developed the HSS sales support system to make the job of its home photovoltaic power

* The initial output of a photovoltaic module is within a tolerance of the nominal output. If the output falls by more than 3.5% from the bottom end of this tolerance range in the first year after the commencement of the warranty, by more than 0.68% annually in subsequent years, or by more than 19.82% over 25 years, the photovoltaic module will be repaired or replaced under warranty, or additional modules will be installed.

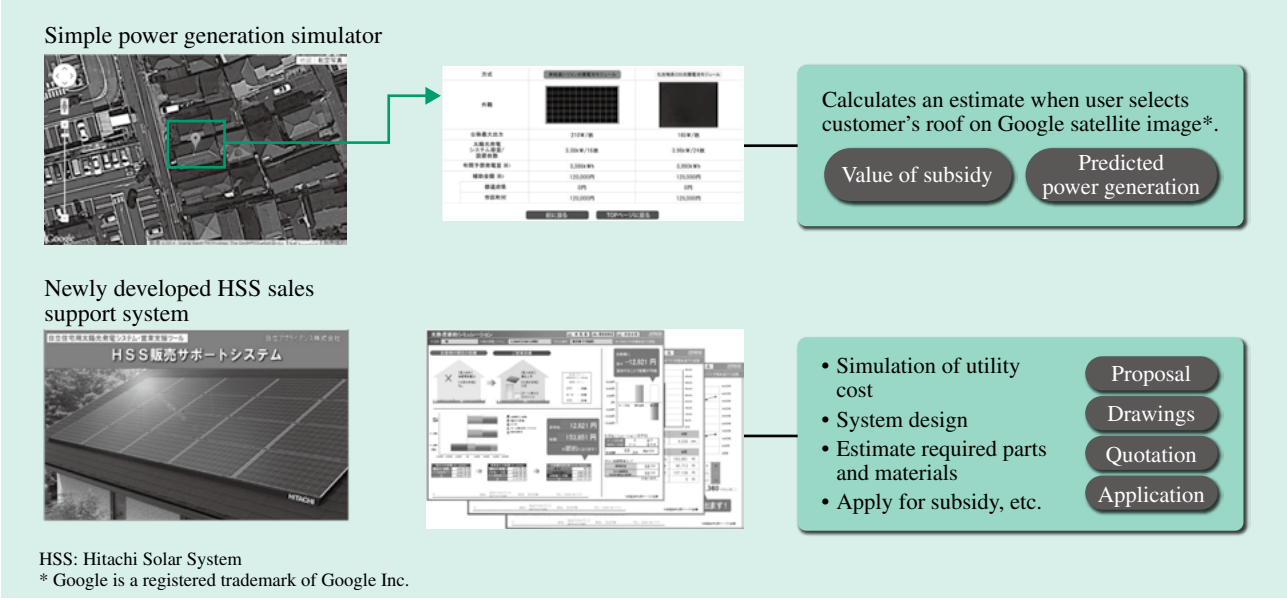


Fig. 5—Sales Support Tool Functions.
Hitachi developed a tool for simulating how photovoltaic modules will perform when installed on the roof of a home, and a sales support tool for generating proposals, drawings, and quotations for photovoltaic power generation systems.

generation system retailers easier. It includes selling system products required for installation, providing customers with system proposals or quotations, supplying application documents, and supplying drawings for installers.

Users who log in to the HSS sales support system on the website from a personal computer (PC) can access a service that, by entering the required information such as details of the roof and choice of photovoltaic modules to install, will not only automatically provide them with information such as photovoltaic module and mounting rail layout drawings while calculating the required quantities of installation fittings, it will also generate proposal, quotation, drawing, and application documents. This service can be accessed from a closed website exclusively for accredited retailers and other suppliers of Hitachi home photovoltaic power generation systems.

Because the support service manages customer details and equipment and other system configuration data centrally on a server, in addition to sales support, it also provides the infrastructure to ensure customers enjoy trouble-free use of their photovoltaic power generation system by linking to customer management and maintenance services such as periodic inspections (see Fig. 7).

HSS Accreditation Scheme

To ensure the quality of its systems and that customers can feel confident about using them, Hitachi has

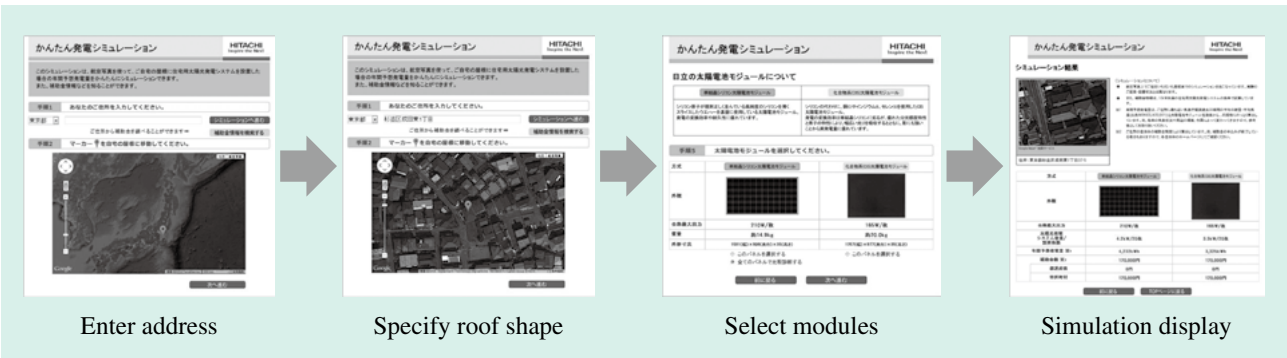


Fig. 6—Simple Power Generation Simulator Screens.
The user specifies the home's address to find its roof, and selects which photovoltaic modules to install. The simulator then uses this information to calculate how much power the system will generate based on local weather data.

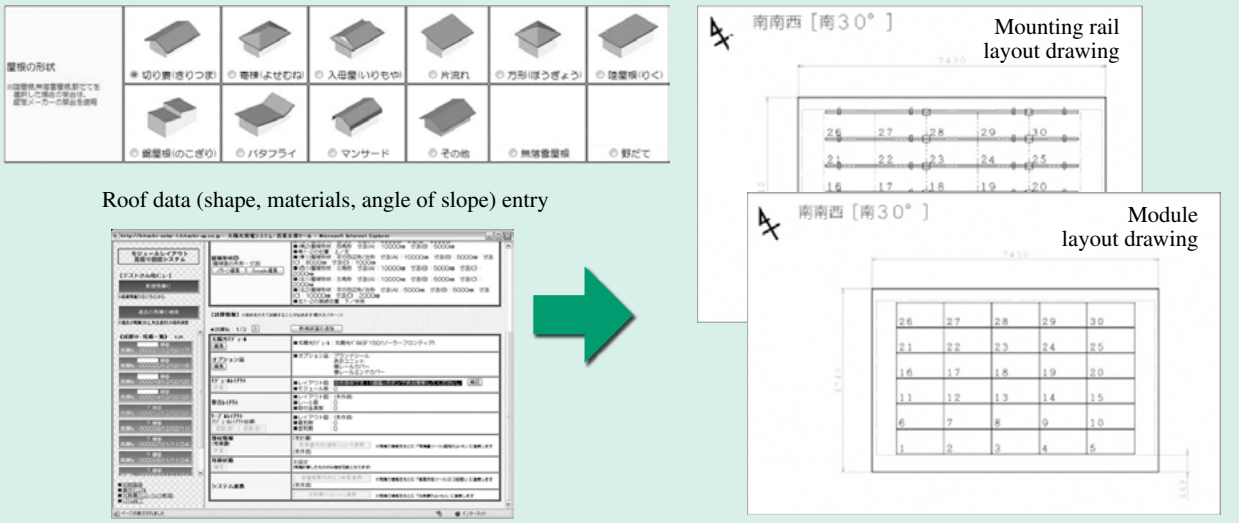


Fig. 7—User Screens from HSS Sales Support System.
When the user enters roof data (shape, materials, etc.), customer details, and other required information, the system automatically generates documents such as photovoltaic module and mounting rail layout drawings.

established three vocational qualifications for retailers and installers: HSS Master, HSS Advisor, and Accredited HSS Installer. Hitachi operates this accreditation scheme and trains accredited staff to ensure the quality of installation work, and that staff are able to provide customers with quotations and handle other sales activities. The accreditation identification (ID) awarded to people who complete the training also gives them access to the HSS sales support system (see Fig. 8).

HSS accreditations and type of work

Role	Type	For	Type of work
Management	HSS Master	Hitachi sales staff	• Advisor training • Consultation of whether to install • Management of installers
Sales	HSS Advisor	Retailer staff Trade customers	• Site survey (simple) • Commercial negotiation • Quotation • Ordering
Installation	Accredited HSS Installer	Installers (electrical installation is performed by electricians with the Second Class Electric Work Specialist qualification)	• Project management • Installation • Application preparation • Decision whether to install • Site survey • Preparation and submission of work completion report

Sequence of steps for acquiring HSS accreditation

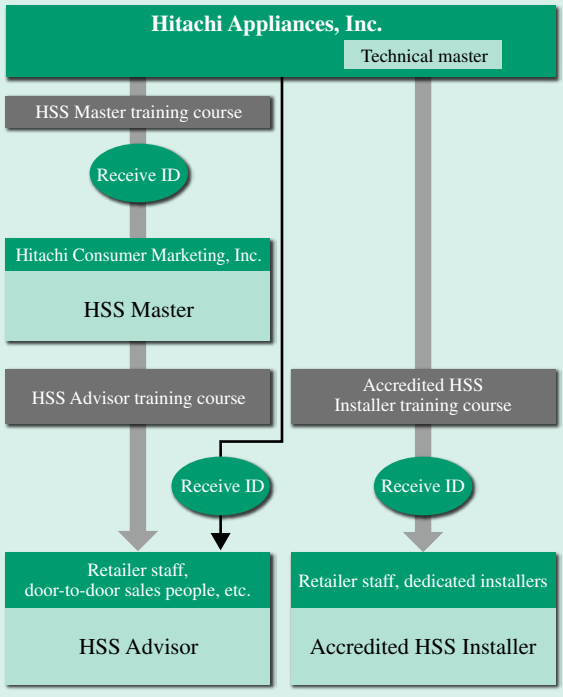


Fig. 8—HSS Accreditation Scheme.
Hitachi has established three qualifications for its photovoltaic power generation systems: HSS Master, HSS Advisor, and Accredited HSS Installer.

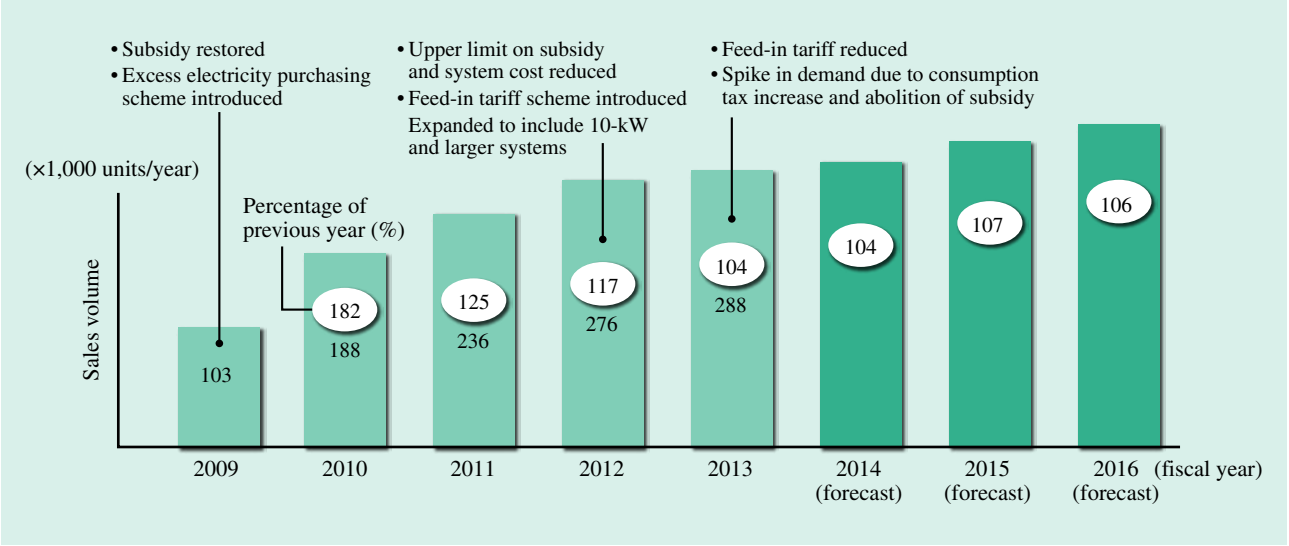


Fig. 9—Trend in Demand for Home Photovoltaic Power Generation Systems.
The graph shows forecasts collated by the Japan Photovoltaic Energy Association and Hitachi Appliances, Inc.

DEMAND TRENDS AND FUTURE SALES INITIATIVES

Trends in Demand for Home Photovoltaic Power Generation Systems

Since the 2009 restoration of subsidies for the installation of home photovoltaic power generation systems, the market for these systems has experienced steady growth underpinned by initiatives such as Japan's excess electricity purchasing scheme (since replaced). In addition to consideration of the environment and rising awareness of energy efficiency and the need to save electricity, it is anticipated that concerns about such things as the supply and demand of electric power and price increases will lead to ongoing growth in demand, with a steady rise in the number of customers installing photovoltaic power generation systems they can use in their homes (see Fig. 9).

Future Plans for Home Photovoltaic Power Generation Business

Hitachi's home photovoltaic power generation system business was initially established to target home systems sold by Hitachi chain stores (distributors and retailers of Hitachi-brand products). Hitachi is now seeking to increase sales by expanding this to also include wholesalers, door-to-door sellers, and other vendors. To expand its photovoltaic power generation system business, Hitachi also intends to sell its power conditioner (a key component of its photovoltaic power generation system) as a standalone product, with a target of selling 30,000 units annually, which will give it 5% of the market by volume for power conditioners in 2015.

CONCLUSIONS

This article has described the Hitachi home photovoltaic power generation system that first went on sale in 2012.

Hitachi Appliances, Inc. develops and manufactures home appliances and domestic and commercial air conditioners that feature excellent energy efficiency. Along with these energy-efficient products, the company's product range encompasses models for saving, storing, and generating energy in the home. These include energy-efficient water heaters with a hot water tank as thermal storage, and photovoltaic power generation systems that produce energy. In the future, Hitachi intends to continue working with its partners to develop products that contribute to the environment, including this range of appliances that provide highly efficient use of energy in the home.

REFERENCE

(1) Japan Photovoltaic Energy Association (JPEA), http://www.jpea.gr.jp/

ABOUT THE AUTHORS

Kenji Shiraishi

New Energy System Planning Department, Business Management Division, Eco Appliances Business Group, Hitachi Appliances, Inc. He is currently engaged in the business planning for photovoltaic power generation.

Akihiko Kanouda

Information and Control Systems Research Center, Hitachi Research Laboratory, Hitachi, Ltd. He is currently engaged in the development of power supply circuits and control technologies. Mr. Kanouda is a member of The Institute of Electrical Engineers of Japan (IEEJ) and The Institute of Electronics, Information and Communication Engineers (IEICE).

Satoru Usui

New Energy System Planning Department, Business Management Division, Eco Appliances Business Group, Hitachi Appliances, Inc. He is currently engaged in the business planning for photovoltaic power generation.